Responding to Climate Change in New York State

The ClimAID Integrated Assessment for Effective Climate Change Adaptation Strategies

Daniel Bader

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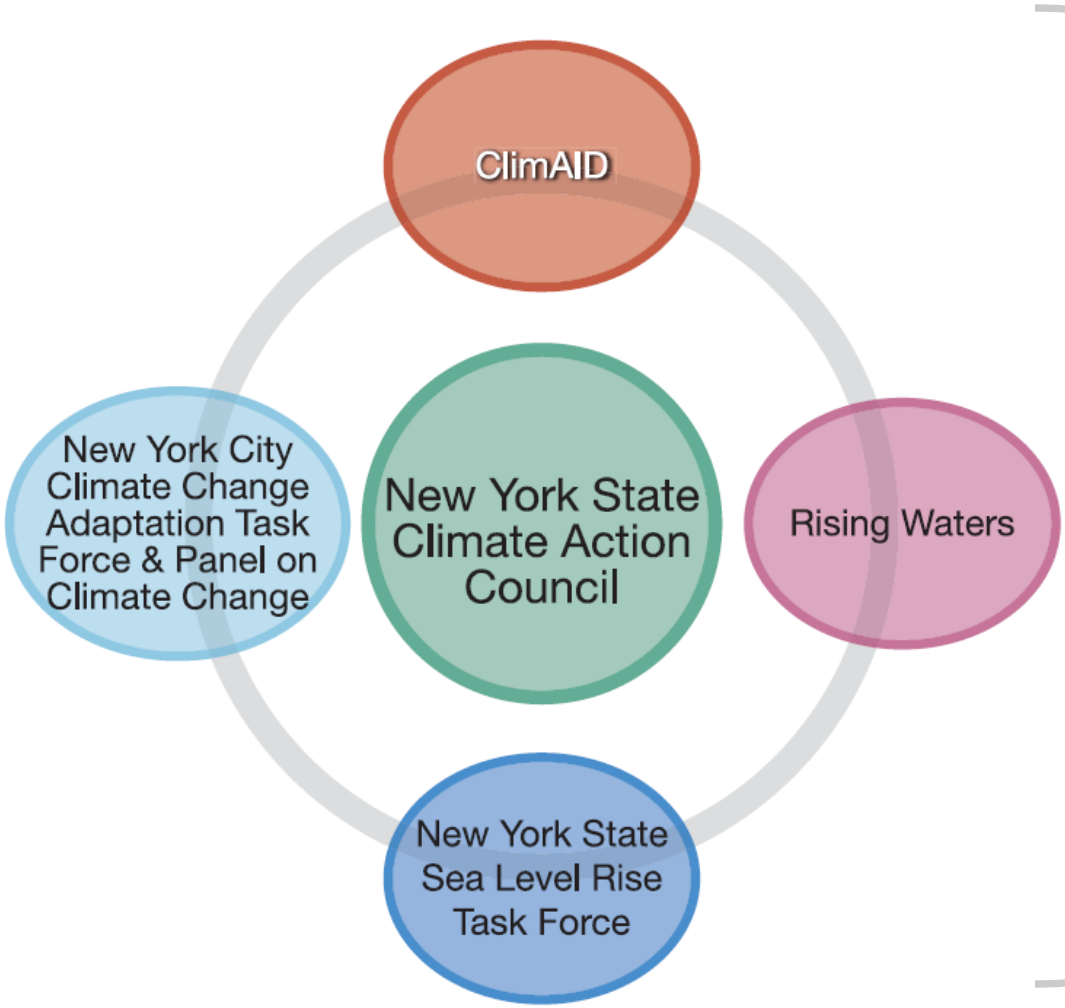
NYSERDA
CENTER FOR CLIMATE SYSTEMS RESEARCH
THE EARTH INSTITUTE AT COLUMBIA UNIVERSITY
Cornell University
The INSTITUTE for SUSTAINABLE CITIES
CITY UNIVERSITY OF NEW YORK

ClimAID Goals

To provide New York State with cutting-edge information on its vulnerability to climate change and to facilitate the development of adaptation policies informed by both local experience and state-of-the-art scientific knowledge.

ClimAID in Context

Interactions of the ClimAID Assessment with other climate change adaptation initiatives in New York State



Now contributing to the US National Climate Assessment, including the Northeast and Urban technical reports

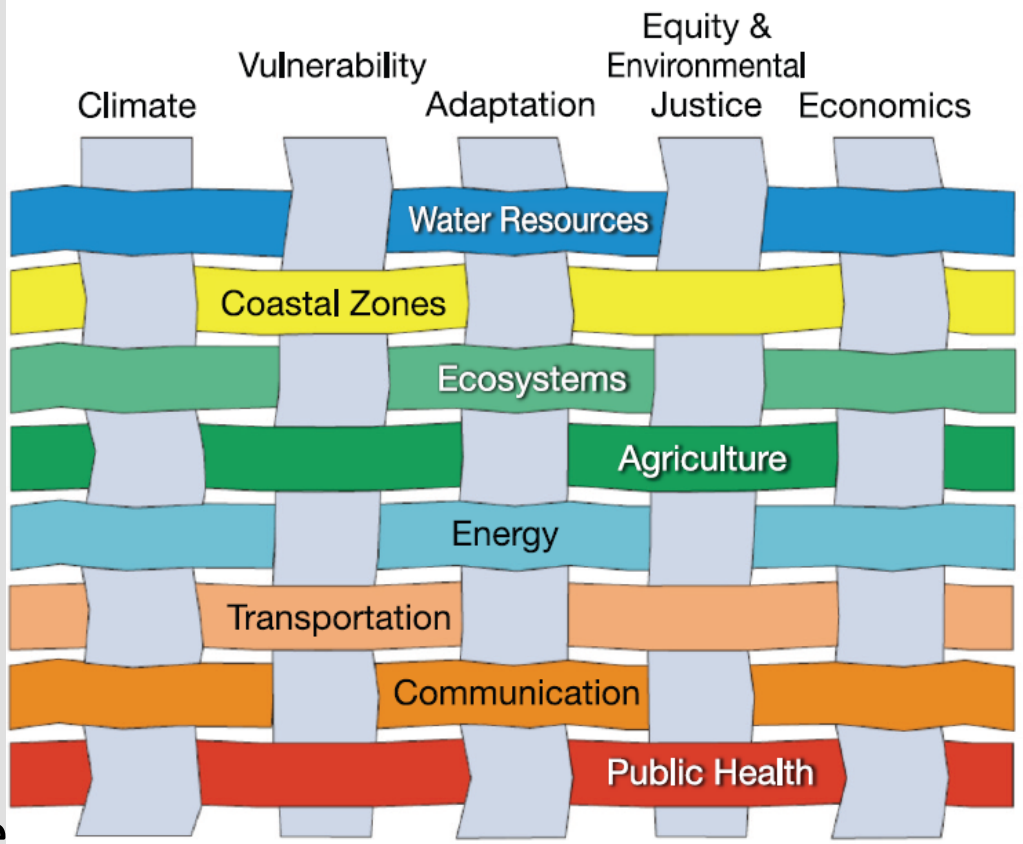
Structure

Sectors

- Water Resources
- Coastal Zones
- Ecosystems
- Agriculture
- Energy
- Transportation
- Telecommunications
- Public health

Integrating Themes

- Climate
- Vulnerability
- Adaptation
- Equity & Environmental Justice
- Economics



ClimAID Case Studies

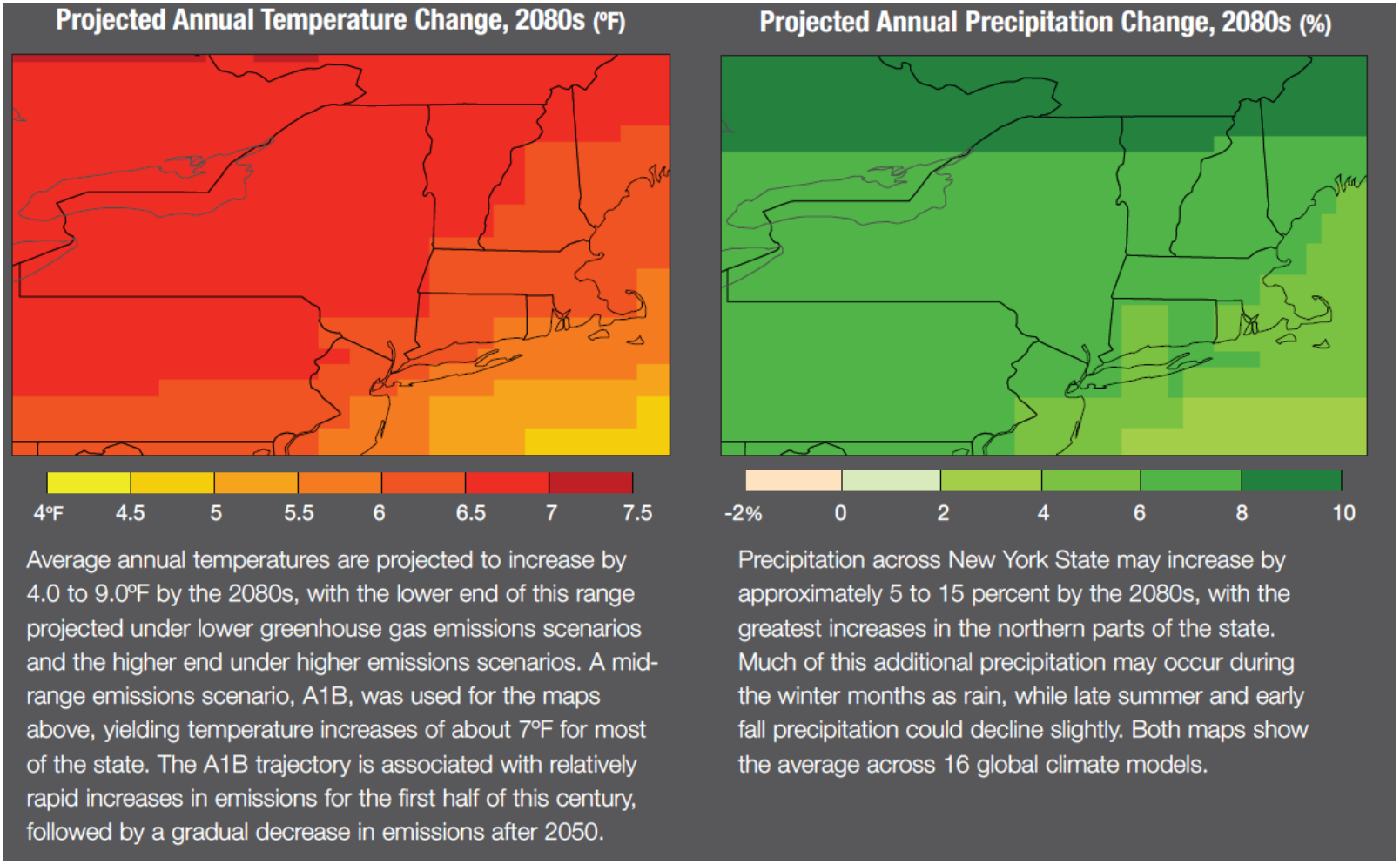
In-depth case studies including economic and environmental justice analysis

Sector	Case Study Title
Water Resources	Susquehanna River Flooding, June 2006
Coastal Zones	1-in-100-Year Flood and Environmental Justice
Ecosystems	Brook Trout – Reduction in Habitat Due to Warming Summers
Agriculture	Dairy Heat Stress
Energy	Climate Change-Induced Heat Wave in New York City
Transportation	Future Coastal Strom Impacts on Transportation in the New York Metropolitan Region
Telecommunications	Winter Storm in Central, Western, and Northern New York
Public Health	Heat-related Mortality Among People Age 65 and Older

Additional case studies found in the report

New York State Climate Regions

Integrating Mechanisms Climate

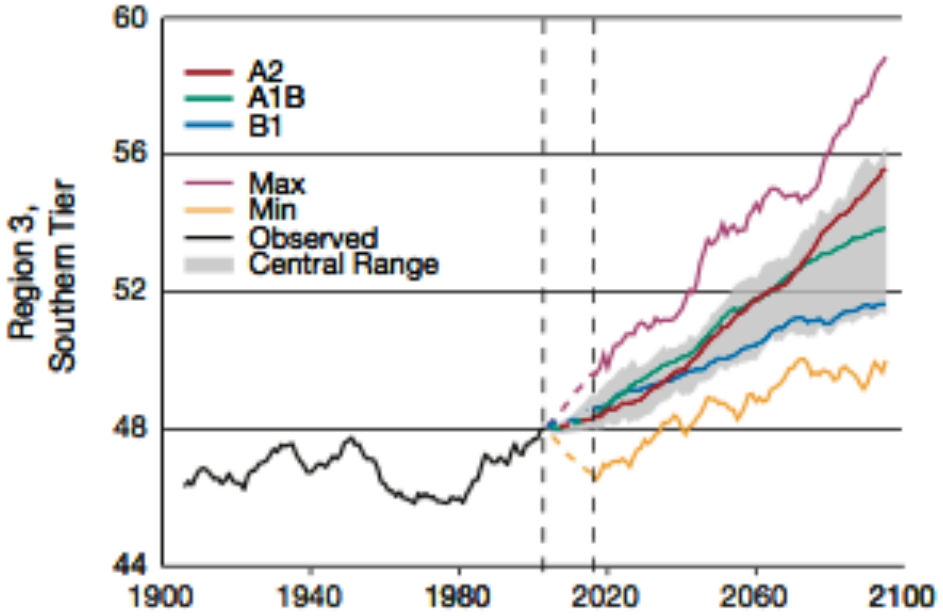


Average annual temperatures are projected to increase by 4.0 to 9.0°F by the 2080s, with the lower end of this range projected under lower greenhouse gas emissions scenarios and the higher end under higher emissions scenarios. A mid-range emissions scenario, A1B, was used for the maps above, yielding temperature increases of about 7°F for most of the state. The A1B trajectory is associated with relatively rapid increases in emissions for the first half of this century, followed by a gradual decrease in emissions after 2050.

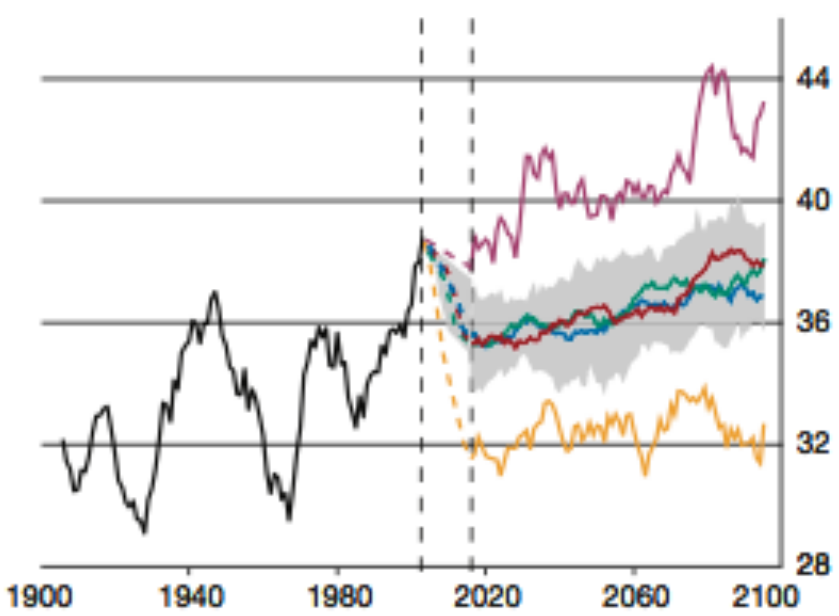
Precipitation across New York State may increase by approximately 5 to 15 percent by the 2080s, with the greatest increases in the northern parts of the state. Much of this additional precipitation may occur during the winter months as rain, while late summer and early fall precipitation could decline slightly. Both maps show the average across 16 global climate models.

Integrating Mechanisms Climate

Average Annual Temperature



Total Annual Precipitation



Climate Projections

- 16 Global Climate Models
- 3 Greenhouse gas emission scenarios
- Statistically downscaled to ClimAID regions

Integrating Mechanisms Climate

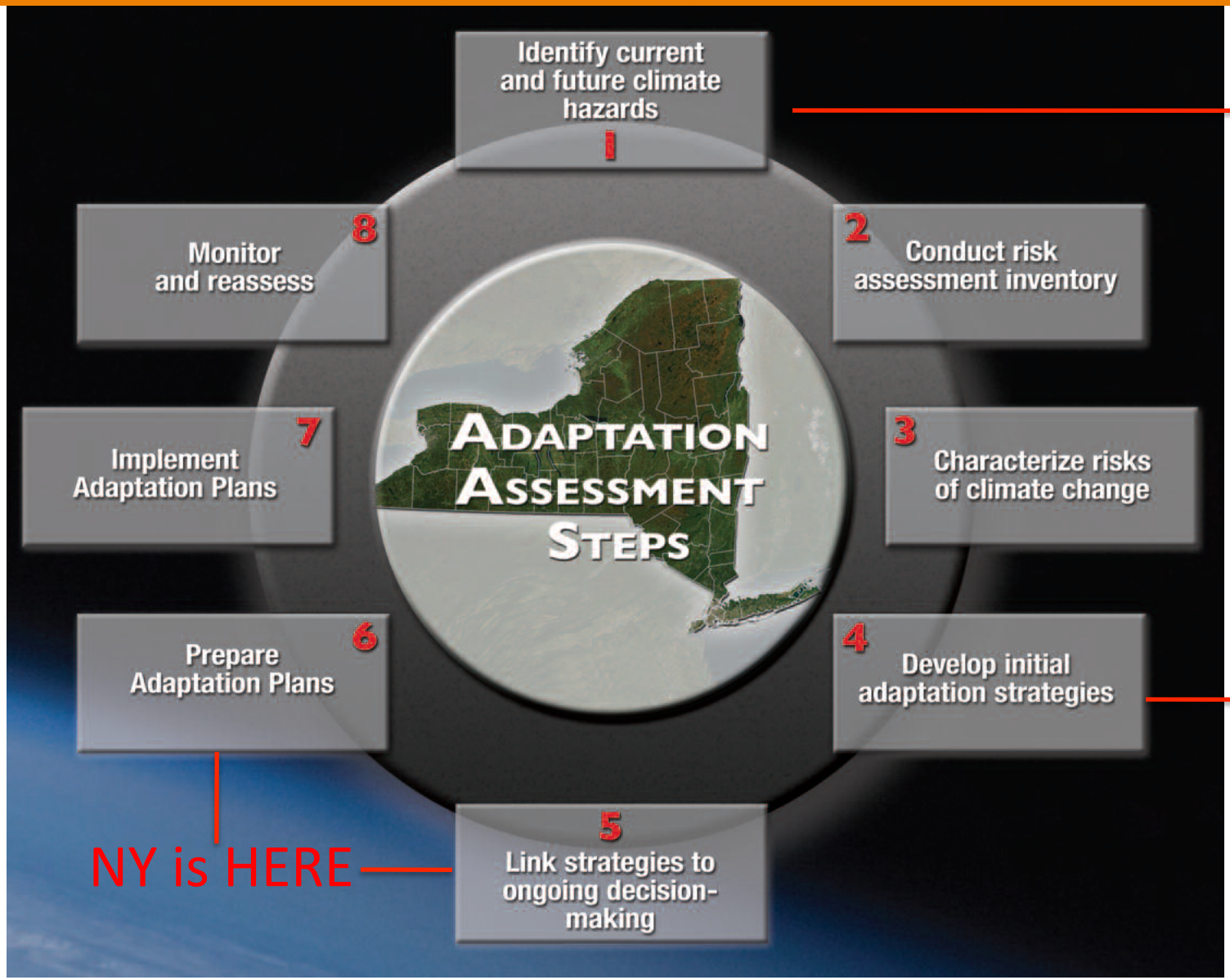
Projected Sea Level Rise for New York State (inches)

Modeled Sea Level Rise	2020s	2050s	2080s
GCM-based	+1 to +5	+5 to +12	+8 to +23
Rapid Ice Melt Scenario	+4 to +10	+17 to +29	+37 to +55

Changes in extreme events

- Projected increase in heat wave occurrence and magnitude
- Observed and projected increases in heavy rainfall
- Projected increases in short-term summer drought

Integrating Vulnerability and Adaptation



Integrating Vulnerability and Adaptation

Factors Used to Evaluate Vulnerability

- ✓ Magnitude
  - Area or number of people affected; degree of damage caused
- ✓ Timing
  - Near term or distant future
- ✓ Persistence and reversibility
  - Rare events becoming more frequent
- ✓ Likelihood
  - Confidence in estimates
- ✓ Distributional aspects
  - Statewide, within a region or among socio-economic groups
- ✓ Relative importance of the at-risk systems
  - Livelihood dependence on a system
- ✓ Thresholds or tipping/trigger points
  - That could exacerbate change or initiate policy

Integrating Vulnerability and Adaptation

Categories of Adaptation Strategies

- ✓ Type
  - Behavior; Management/operations; Infrastructural/physical component
  - Risk-sharing; Policy (including institutional and legal)
- ✓ Administrative group
  - Public vs. private
  - Governance scale (local/municipal, county, state, national)
- ✓ Level of effort
  - Incremental action, paradigm shift
- ✓ Timing
  - Years to implementation
  - Speed of implementation (near-term/long-term)
- ✓ Scale
  - Widespread, clustered, isolated/unique

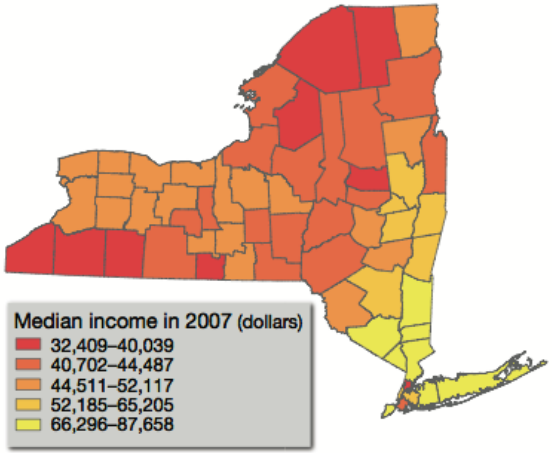
Integrating Vulnerability and Adaptation

Considerations for Evaluating Adaptation Strategies

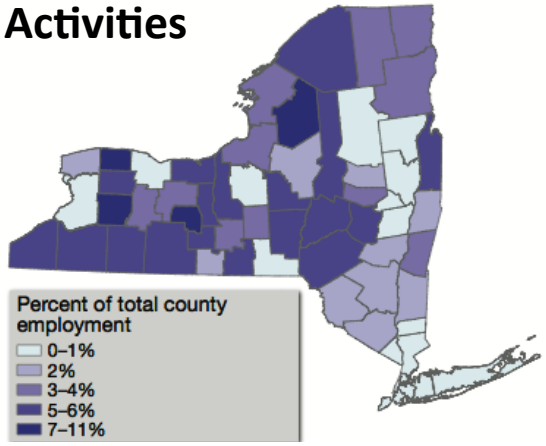
- ✓Cost
  - Estimate benefits and costs
- ✓Feasibility
  - Any technological, legal or policy hurdles?
- ✓ Efficacy
  - To what extent will the strategy reduce the risk?
- ✓ Timing
  - Factors affecting the implementation schedule
- ✓Robustness
  - Flexible adaptation pathways
- ✓ Co-benefits/unintended consequences
  - Mitigation, cross sectors, etc.
- ✓ Resiliency
  - Able to withstand shocks and stress?
- ✓ Impacts on environmental justice communities
  - Negative or positive impacts for communities already stressed by environmental risk exposures?

Equity, Environmental Justice and Economics

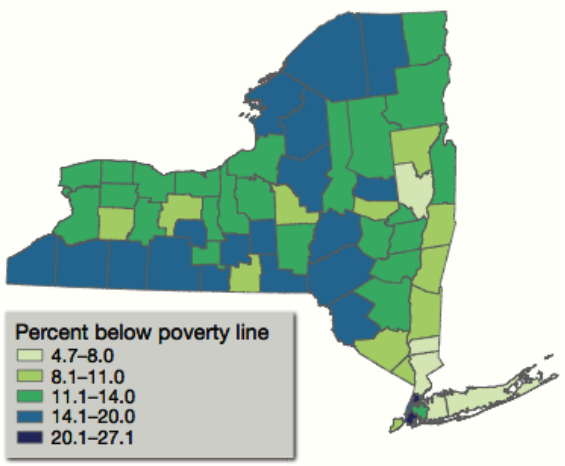
Income Disparities



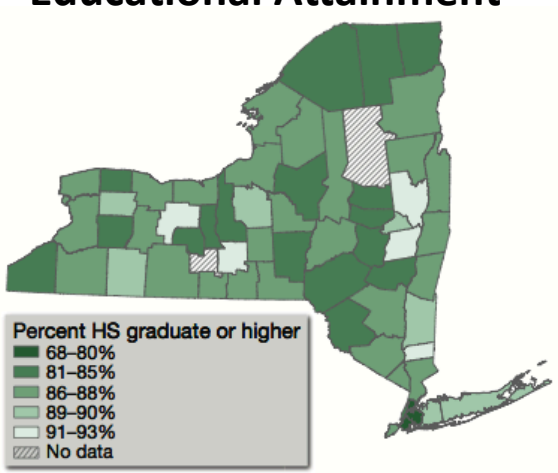
Employment in Agriculture, Forestry, Fishing and Related Activities



Poverty Rates

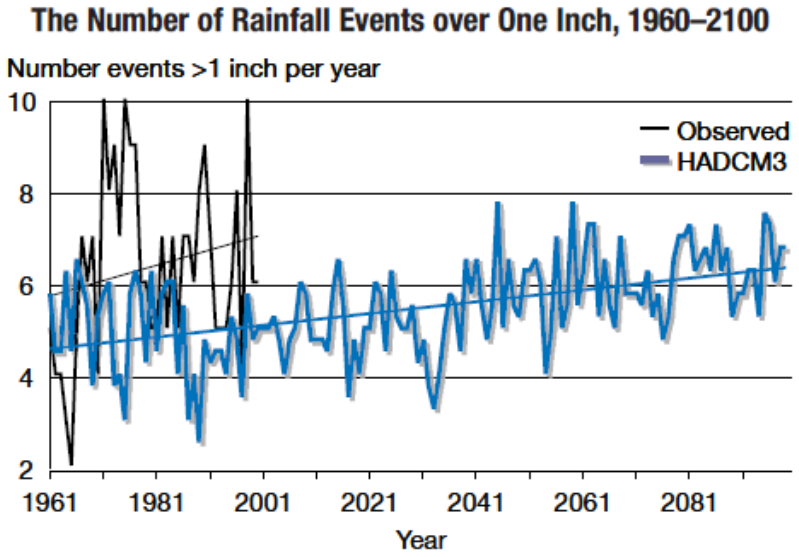


Educational Attainment



Water Resources Key Climate Impacts

- ✓ Heavy rainfall has increased over the last 50 years
  - Trend projected to continue
  - Localized flash flooding
- ✓ Flooding has the potential to increase water pollution
  - Water treatment plants mainly on floodplains
- ✓ Less frequent summer rainfall may affect water supply
  - Primarily on smaller water systems and wells
- ✓ Reduced flows on larger rivers
  - Possible water conflicts (e.g., ag vs domestic)
- ✓ Increased water temperatures
  - Affect aquatic health and ability to



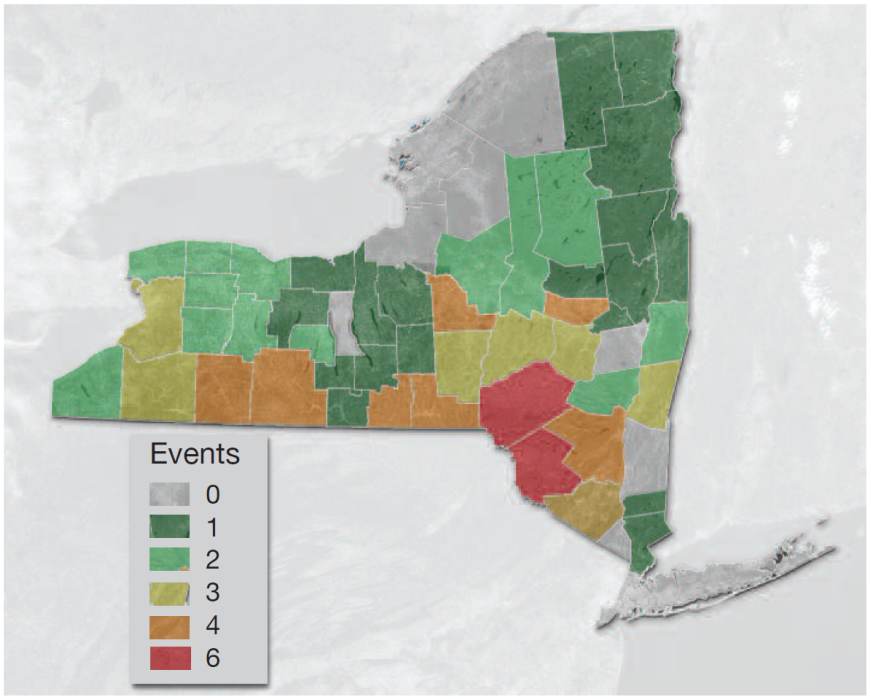
The observed number of rainfall events exceeding one inch from 1960 to 2000 is shown by the black line, and the projected number of such events, using the HadCM3 model, is show by blue line. These results are broadly consistent with those of the other 15 GCMs used by ClimAID.

Water Resources Adaptation

- ✓ Infrastructure
  - Move or protect infrastructure in floodplains
  - Upgrade combined sewer and stormwater systems
- ✓ Increase Efficiency
  - Promote conservation for sustainable supply
- ✓ Develop Strategies
  - Drought management plans
  - Streamflow regulations to mimic natural patterns
- ✓ Expand Basin-Level Commissions
  - Take leadership
  - Improved monitoring and conservation

Water Resources Vulnerable Groups

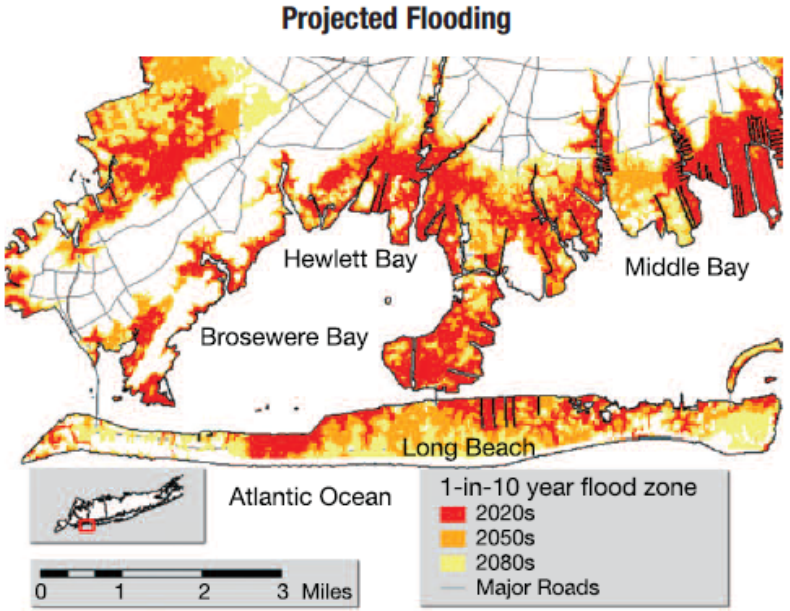
- ✓ Smaller water systems
  - More vulnerable to drought
  - Less closely managed
  - Fewer resources
- ✓ Elderly and disabled
  - Immediate flood hazard …. less mobile
- ✓ Rapidly growing exurban communities
  - Increased demand and competition
- ✓ Low-income and non-English-speaking populations
  - Less aware of programs and warning related to water quality and contamination



Number of FEMA-declared flood disasters in New York State counties. (FEMA)

Coastal Zones Key Climate Impacts

- ✓ Alteration of barrier islands
  - Strong coast storm surge
  - Beach erosion, dune overwash, new inlet creation
- ✓ Inundation of coastal populations due to sea level rise
  - More frequent flooding in area now near seal level
- ✓ Loss of coastal wetlands and salt march stress
  - Reduced species diversity
- ✓ Migration of cold water species
  - Blue claw crabs replace lobster
- ✓ Salt water intrusion on the Hudson
  - Tides, storm surge and salt water propagate upriver



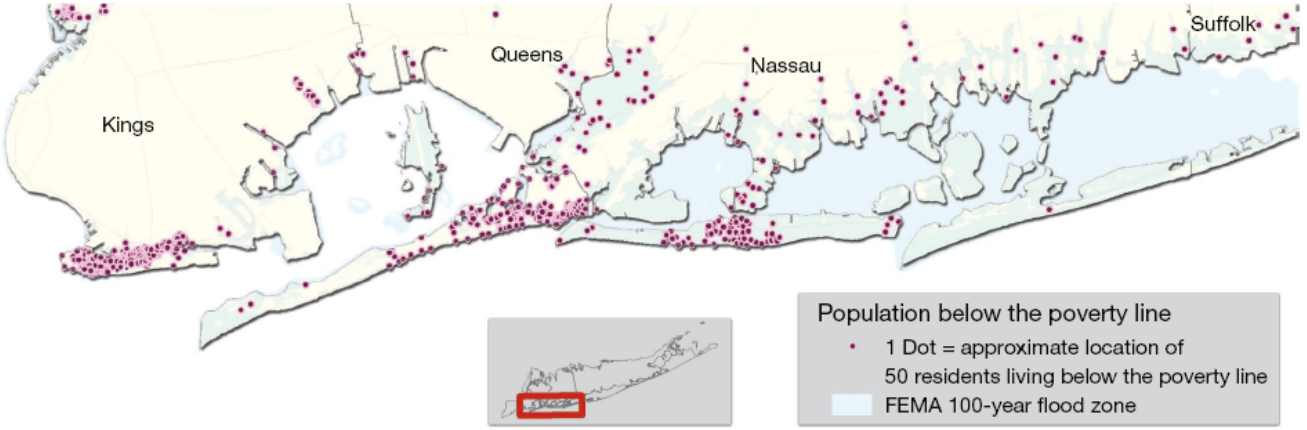
Projected flood map for 1-in-10 year storm event for Long Beach and surrounding bay communities for ClimAID rapid ice melt scenario.

Coastal Zones Adaptation

- ✓ Infrastructure
  - Move or protect infrastructure in zones
  - Upgrade combined sewer and stormwater systems
- ✓ Engineering strategies
  - Build or raise sea walls
  - Move sand to beaches …. temporary solution
  - Construct artificial wetlands
- ✓ Develop strategies
  - Buy out or swap land to encourage exit from flood zones
  - Balance wetland protection and coastal development
  - Improve building codes
  - Reevaluate shoreline setback rules

Coastal Zones Vulnerable Groups

Population in FEMA's 100-year floodplain living below the poverty line

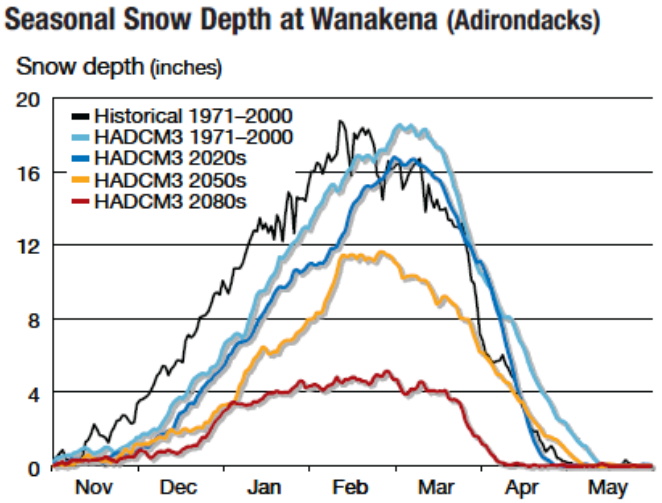


Source: US Census 2000

- ✓ Elderly and disabled
  - Immediate flood hazard …. less mobile
- ✓ Racial and ethnic minorities
  - Significant populations in New York City flood zone
- ✓ Low-income and non-English-speaking populations
  - Less able to recover from flooding than wealthier populations
- ✓ Fresh water ecosystems in estuaries and cold water marine species
  - Saltwater intrusion
  - Warming water temperatures

Ecosystems Key Climate Impacts

- ✓ Changes will favor the expansion of invasive species
  - Generalists such as white-tail deer benefit
- ✓ Longer growing season and possible CO_2 fertilization
  - Increased hardwood productivity
  - Drought and nutrient availability may limit
- ✓ Fast growing plant species see greater benefits
  - Weeds do better!
- ✓ Altered hydrology on streams rivers and lakes
  - Timing and amount of snowmelt change
  - Less ice cover
- ✓ Increased temperature detrimental to brook trout
  - Also species adapted to snow



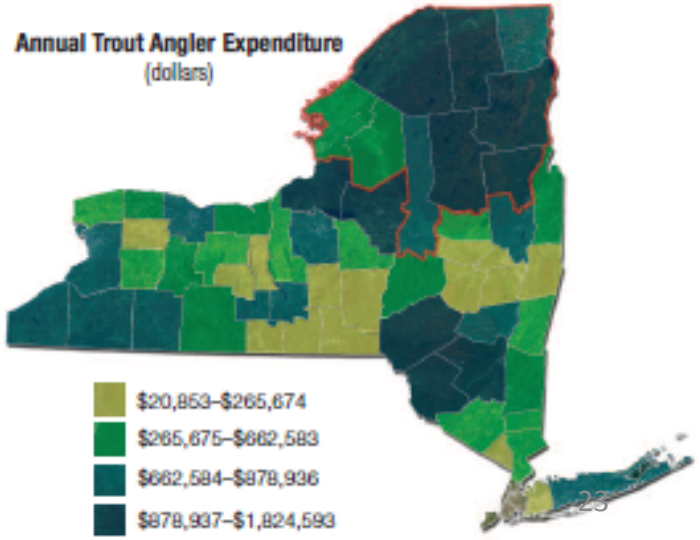
Snowpack is projected to decline sharply due to future warming. The black line shows historical snowpack, and the colored lines show projected snowpack over the months with snow for three future time periods under one relatively high emissions scenario (A2) using one global climate model, UK Met Office Hadley Centre Model version 3 (HadCM3). These projections are broadly consistent with those of other models used in ClimAID.

Ecosytems Adaptation

- ✓Management
  - Reduce vulnerability of high-priority species and communities
- ✓Maintain healthy ecosystems
  - More resilient to change and stress from invasives
- ✓Facilitate natural adaptation
  - Protect riparian zones and migration corridors
- ✓ Comprehensive and coordinated monitoring
  - Track range shifts
  - Prioritization of what to monitor

Ecosystems Vulnerable Groups

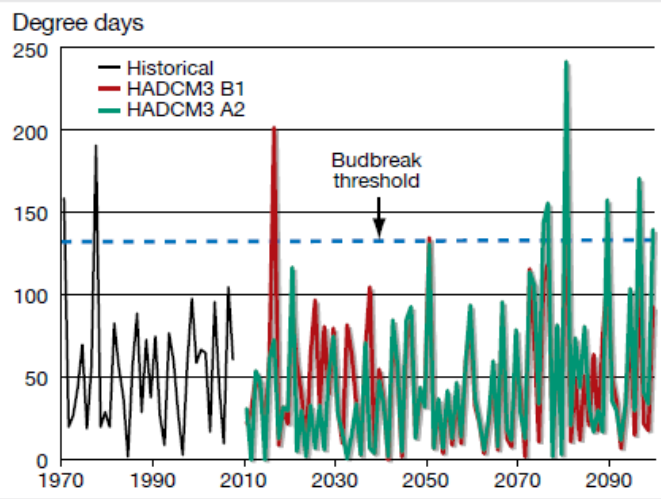
- ✓ Communities reliant on winter sports
  - Less snow for skiing and snow mobiling
- ✓ Communities reliant on cold water fisheries
  - Increases in species such as bass may offset
- ✓ Species that
  - Are adapted to cold and high elevations
  - Have specialized food requirements
  - Are susceptible to new competitors
  - Have poor dispersal ability
- ✓ Examples
  - Spruce…Hemlock….Brook trout….
  - Snowshoe hare….
  - Fox (winter predator)…
  - Baltimore oriole



Agriculture Key Climate Impacts

- ✓ Increased heat stress
  - Crop yield/quality and livestock productivity suffer
- ✓ Increased weed and pest pressure
  - Earlier emergence
  - Greater overwintering potential
- ✓ Opportunities to explore new crops
  - Higher temperatures and longer growing seasons
- ✓ Short-term summer drought risk
  - Also pressures due to rainfall increases (e.g., spring planting)

Projected Degree Days above 60°F Prior to Last Frost



As temperatures rise, plants flower earlier in the spring. This can make them more vulnerable to damage from late spring frost. Climate change has the potential to exacerbate this vulnerability in Concord grapes grown in New York State. The dotted blue line represents a cumulative degree-day threshold that would lead to bud break prior to the last spring frost for Concord grapes in the Fredonia region. Years exceeding the threshold would have a high risk of frost damage. As the chart shows, under a higher emissions scenarios (A2, green line), this is projected happen much more frequently in the later part of this century. These results are broadly consistent with the other global climate models used in ClimAID.

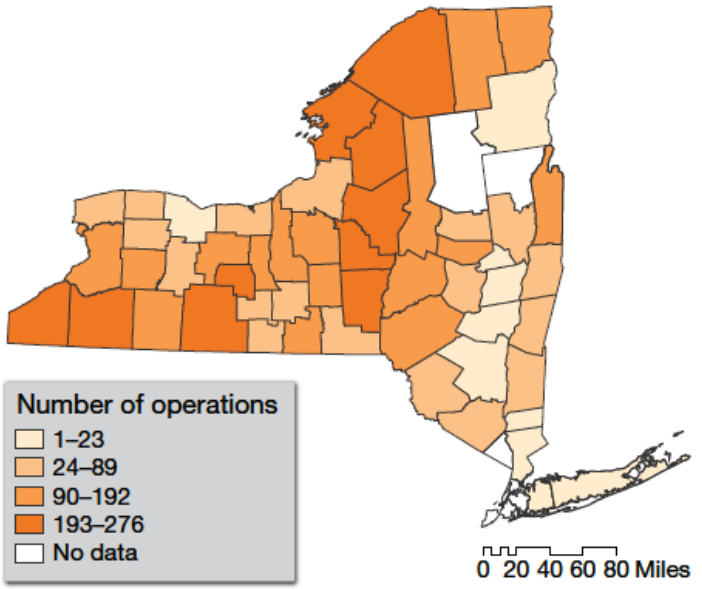
Agriculture Adaptation

- ✓ Infrastructure
  - Increase cooling capacity in dairy facilities
  - Expand supplemental irrigation
  - Improve soil drainage via increase soil organics or tiles
- ✓ Operations
  - Alter planting dates, varieties, crops
  - Diversify
  - Increase pest control… Use new approaches
- ✓ Develop new crop varieties and decision tools
  - Capitalize on climate and market opportunities
  - Tools for adaptation timing & daily operations (e.g., IPM)

Agriculture Vulnerable Groups

- ✓Dairy and cool-season crops
  - Apples, cabbage, potatoes
  - State favorite apple varieties (Macs and Empires)
- ✓Small farms
  - Less capital for adaptation
  - Increase trends toward larger farms (dairy)
- ✓The environment
  - Due to increased pesticide and fertilizer use

Location of dairy operations in New York State



Source: U.S. Agricultural Census, 2007

Energy Key Climate Impacts

- ✓ More heat waves
  - Increased A/C …. increased peak energy loads
- ✓ Increased water and air temperature and sea level rise
  - Decreased efficiency and cooling capacity
  - Vulnerable infrastructure
- ✓ Higher winter temperatures
  - Decreased heating demand
  - Perhaps affecting natural gas markets
- ✓ Increased challenges for renewables
  - Hydropower…. Summer drought
  - Solar and wind …. Uncertainty in clouds/wind
  - Biomass depends on growing season conditions

Projected Changes in Peak Electricity Demand for Heating and Cooling, 2020s (compared to current peak demand)

Weather Station	Heating Season **Decrease** in MWp Electricity Demand in 2020s	Cooling Season **Increase** in MWp Electricity Demand in 2020s
Buffalo	14–27	55–111
Rochester	9–18	53–105
Syracuse	19–37	61–122
Massena	5–10	7–15
Watertown	11–21	29–57
Albany	15–29	63–126
Poughkeepsie	12–25	72–145
NY City (LGA)	40–80	249–497
Islip	27–58	194–387

ClimAID global climate models project that average annual temperature will rise by 1.5 to 3.0°F in the 2020s compared to the 1970–1999 baseline period. An analysis of the sensitivity of energy demand to these changes shows that while heating energy use will decrease slightly, cooling energy use will increase much more.

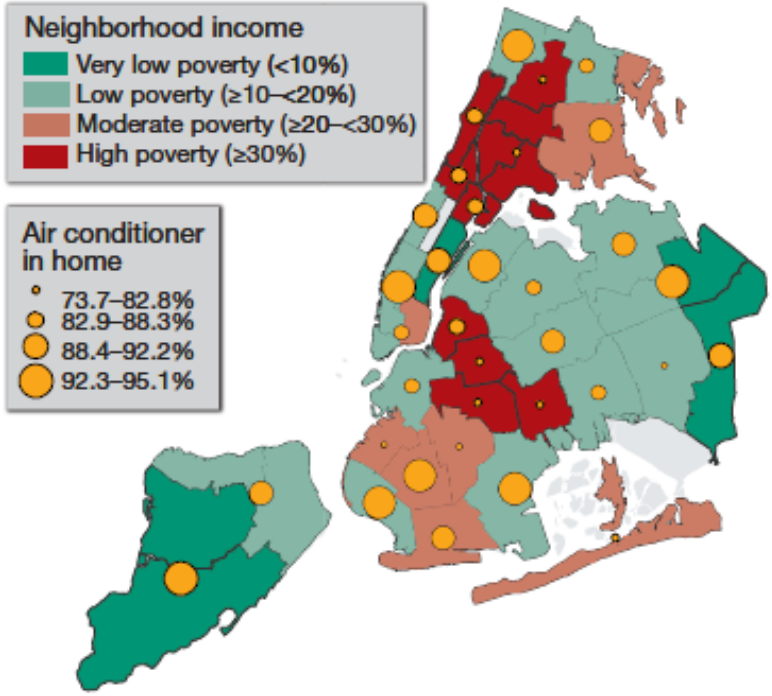
Energy Adaptation

- ✓Infrastructure
  - Berms and levees to protect from flooding
  - Salt-water resistant transformers
  - Transformers and wires that maximize high temperature efficiency
- ✓Operations
  - Adjust reservoir release practices for hydropower
- ✓Policies
  - Improve energy efficiency in high demand sectors

Energy Vulnerable Groups

- ✓ Lower-income residents
  - Increased energy costs with AC
  - Especially in urban areas (heat island effects)
- ✓ Communities
  - New energy facilities will place burdens on nearby towns
- ✓ Elderly and disabled
  - More vulnerable to energy outages

Air Conditioning Distribution and Neighborhood Level Poverty



Neighborhoods with higher poverty rates, including Central Harlem, Washington Heights, Fordham, the South Bronx, Greenpoint, Williamsburg, Bedford-Stuyvesant, and others, have lower rates of in-home air conditioning than more affluent parts of the city.

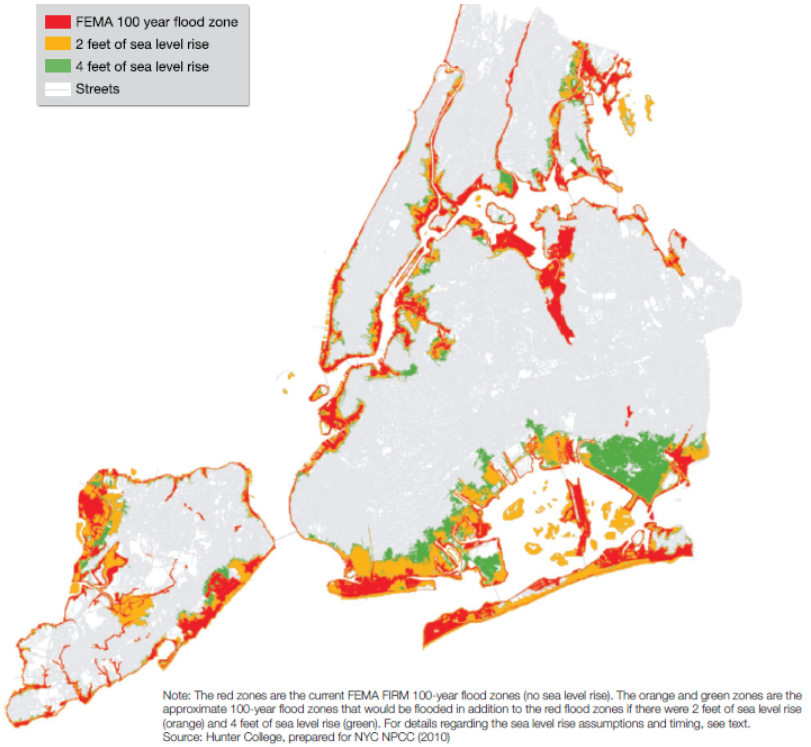
Transportation Key Climate Impacts

- ✓ Heavy precipitation
  - Street flooding and mass transit delays
- ✓ Sea level rise
  - Subways and tunnels at risk of flooding
  - Railways along Hudson vulnerable to flooding
  - Coastal roadways and interstates
- ✓ High temperatures
  - Increased AC needs on mass transit
  - Longer runways
  - Asphalt and train rail stresses
- ✓ Great Lakes ice cover
  - Longer shipping season
  - More lake effect snow

Transportation Adaptation

- ✓ Infrastructure
  - Sea walls and levees to protect from flooding
  - Pumping facilities
  - Elevate roads, bridges, etc.
  - Relocate out of flood zones
  - Lengthen runways
- ✓ Operations
  - Engineering-based risk assessments of operations
- ✓ Policies
  - Changes in engineering design specifications
  - Form alliances to reduce risks
  - Mutual insurance pools to spread risks

100-year flood zones in New York City (i.e., with a probability of being flooded of 1 percent per year) for current and two different ClimAID sea level rise scenarios



Note: The red zones are the current FEMA FIRM 100-year flood zones (no sea level rise). The orange and green zones are the approximate 100-year flood zones that would be flooded in addition to the red flood zones if there were 2 feet of sea level rise (orange) and 4 feet of sea level rise (green). For details regarding the sea level rise assumptions and timing, see text.
Source: Hunter College, prepared for NYC NPCC (2010)

Transportation Vulnerable Groups

- ✓Urban low-income and elderly populations
  - Vulnerable to public transportation disruptions
  - Limited abilities to evacuate
- ✓Working women
  - Transportation interruptions affect child and family care time
- ✓Hourly workers
  - Transportation-related work loss affects income
- ✓Lower-income neighborhoods – rural, suburban, urban
  - Poor transportation options little redundancy

Telecommunications Climate Impacts

- ✓Heat waves
  - Telecommunications systems vulnerable to power outages
- ✓Heavy rain, flooding and sea level rise
  - Increased vulnerability of infrastructure

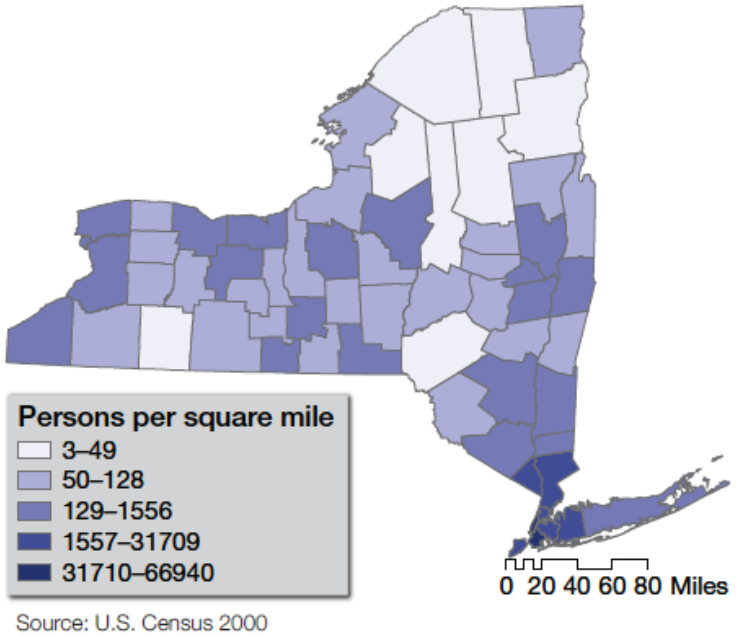
Telecommunications Adaptation

- ✓ Infrastructure
  - Backup power for cell towers
  - Relocation from flood zones
  - Use underground cabling
  - Standardize car charging interfaces for cell phones
- ✓ Policy
  - Better regulation enforcement (e.g., reporting of outages)
  - High-speed broadband in rural and low population areas
  - Decouple communications from electric grid
  - Expand alternative communications technologies

Telecommunications Vulnerable Groups

- ✓Customers in rural, remote areas
  - Fewer backup options
  - Lack wireless and broadband services
  - Typically last to have service restored
- ✓Lower-income populations
  - Limited communication options (cell, landline, etc.)

Variation in population density in New York State

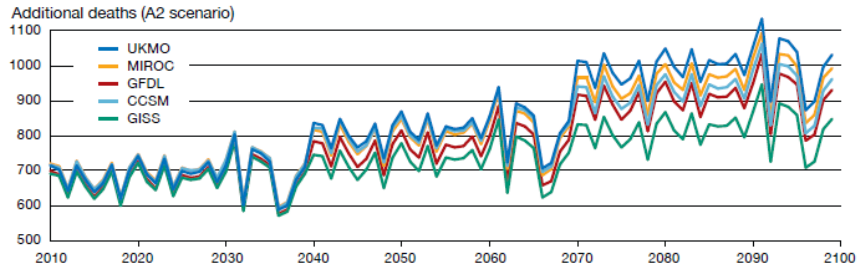


Source: U.S. Census 2000

Public Health Key Climate Impacts

- ✓ Increased temperature
  - Heat-related illness and death will increase
  - Cold-related deaths decrease, but do not compensate
- ✓ Worsening air quality (smog, wildfires, pollen)
  - Increased cardiovascular and respiratory illness and death
- ✓ Vector-borne disease spread
  - For example, West Nile Virus and Lyme disease
- ✓ Flooding from heavy rain
  - Water and food-borne disease risk
  - Increased stress and mental health problems
  - Recreational water quality compromised

Projected temperature-related deaths in NY county



As climate continues to warm, heat-related deaths are expected to increase, while cold-related deaths are expected to decrease. A preliminary study of all of these temperature-related deaths from 2010 to 2100 in New York County was undertaken using 5 climate models from the set of ClimAID models under lower (B1) and higher (A2) emissions scenarios. The results suggest that increases in heat-related deaths will outweigh reductions in cold-related deaths, resulting in a net increase in deaths due to climate change. The lower-emission scenario (B1) is projected to result in substantially fewer deaths by the 2080s. The chart shows the results from 5 models for the higher (A2) emissions scenario. These results are broadly consistent with the other global climate models used in ClimAID.

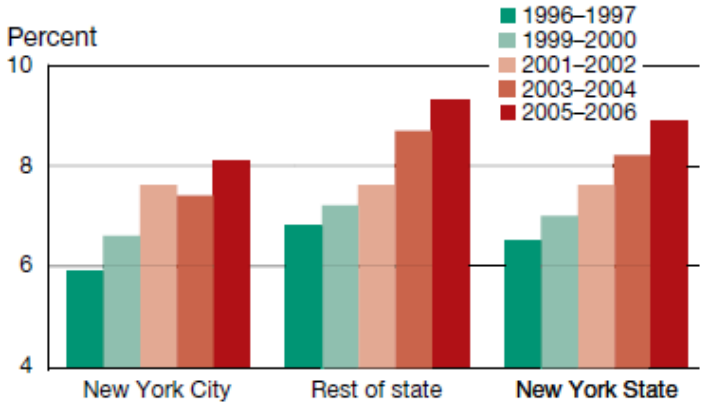
Public Health Adaptation

- ✓Operations
  - Extend surveillance of climate and heath indicators
  - Statewide monitoring of pollen and mold
  - Plant low-pollen urban trees
- ✓Management
  - Evaluate heat response plans
  - Expand cooling center access
- ✓Policy
  - Tie environment and human health initiatives, as they are often related

Public Health Vulnerable Groups

- ✓ Urban elderly, children, immune-impaired, low-income
  - Particularly vulnerable to heat-related risks
- ✓ Northern populations
  - Less accustomed to extreme heat
- ✓ Asthma suffers
  - Vulnerable to increased ozone and other pollutants
- ✓ Children, athletes, outdoor laborers
  - Greater exposure to heat and respiratory disease
- ✓ Coastal and floodplain residents
  - Evacuation stress
  - Mold and toxic exposure post-flood

Prevalence of current asthma among adults, by region



Source: Figure 5-2 of New York State Asthma Surveillance Report, October 2007, accessed March 18, 2009 at http://www.health.state.ny.us/diseases/ asthma/

Conclusions

- ✓ Success of NY's response will depend on effective adaptation strategies
- ✓ Climate change brings opportunities and challenges
  - Climate interacts with (exacerbates) existing stressors
- ✓ Sea level rise and coastal flooding greatest challenge
  - Affect multiple sectors and large populations
- ✓ Many adaptation needs can occur near term and at modest cost
  - Presents opportunities for co-benefits
  - Infrastructure investment already needed
- ✓ Scientist-policy maker dialogue imperative

Recommendations NY Decision-makers

- ✓Improve climate change awareness
  - Public and private stakeholders
  - General public
- ✓Consider regional, federal, international adaptation options
  - NY will be affected by these policies
- ✓Address environmental justice issues related to climate
- ✓Promote incremental and flexible adaptation strategies
- ✓Identify mitigation and adaptation synergies

Recommendations Stakeholders

- ✓ Integrate adaptation with everyday operations
  - Assess potential for complementary effects
  - Be aware of unintended consequences
- ✓ Evaluate design and performance standards and regulations
  - Consider up-to-date climate projections
- ✓ Identify partnership opportunities
  - Within New York State and more broadly

Recommendations Science & Research

- ✓Develop mitigation and adaptation decision tools
  - Database of risk and adaptation information
  - Targeted impacts research
- ✓Refine climate change scenarios
  - New model runs and downscaled products
- ✓Implement indicators and monitoring programs
  - Improved mapping and spatial tools
- ✓Research
  - "Tipping points"
  - Climate variability, extreme events, wind patterns, etc.
- ✓ Advance cost-benefit analysis